MINOR STUDIES FROM THE PSYCHOLOGICAL LABORATORY OF WILLIAM SMITH AND HOBART COLLEGES.

Communicated by F. M. KUNKEL and G. J. RICH.

I. THE COMPARATIVE SAPIDITY OF HYDROCHLORIC, SULPHURIC AND ACETIC ACIDS.

By L. GIBSON and T. HARTMAN

Corin[1] compared the sapidity of acids by determining the strength of supraliminal solutions with equal tastes, and found that the power to produce taste was not constant either for equal concentrations or for equal numbers of hydrogen-atoms in solution, but that it was greater as the molecular weight of the acid was less, although not in a numerical proportion. Richards,[2] who also equated supraliminal solutions, found that sapidity varied with the degree of ionization of the acid, save that certain weak organic acids were more effective than their degree of ionization would warrant. Kahlenberg[3] used similar methods and came to the same conclusions, noting especially that acetic acid had a stronger taste than was to be expected from the dissociation theory. Kastle[4] obtained like results and suggested that the 'coefficients of affinity' of the acids were effective in producing taste. Crozier[5] made rough determinations of the stimulus-limen for hydrochloric and acetic acids, again finding that the latter acid was more stimulating than could be accounted for by the degree of its dissociation. The stimulus-limen had already been used by Gley and Richet,[6] who found that the taste of the alkali metals depended upon their molecular weights, and by Hober and Kiesow,[7] whose results showed that the limens for salts and for bases remained approximately constant when expressed in terms of ionic concentration. The purpose of the experiments reported here was to apply this same criterion of sapidity, the stimulus-limen, in the case of acids, using a standard psychophysical procedure.

[1] J. Corin, Action des acides sur le goût, *Arch. d. biol.*, 8, 1888, 121ff.

[2] T. W. Richards, The Relation of the Taste of Acids to their Degree of Dissociation, *Amer. Chem. Jour.*, 20, 1898, 121; *Jour. Phys. Chem.*, 4 1900, 207.

[3] L. Kahlenberg, The Action of Solutions on the Sense of Taste, *Bull. Univ. Wisconsin*, 2, 1898, 2ff.; The Relation of the Taste of Acids to the Degree of Their Dissociation, *Jour. Phys. Chem.*, 4, 1900, 33ff.

[4] J. H. Kastle, On the Taste and Affinity of Acids, *Amer. Chem. Jour.*, 20, 1898, 466.

[5] W. J. Crozier, The Taste of Acids, *Jour. Comp. Neur.*, 26, 1916, 453ff.

[6] E. Gley and C. Richet, Action chemique et sensibilité gustative, *Comp. rend., Soc. de biol.*, 37, 1885, 742ff.

[7] Hober and Kiesow, Ueber den Geschmack von Salzen und Laugen, *Zeit. f. phys. Chem.*, 27, 1898, 601ff.

Each of the writers acted as observer for the other. Before starting the main part of the experiment, each went through about two months of preliminary training in order to determine the strength of the solutions which were to be used as stimuli, and to overcome the effects of initial practice. The limens were obtained by the Method of Constant Stimuli, fifty series of five stimuli each being used. Beginning with distilled water in every case, the stimuli differed by .01576 grams per liter in the case of hydrochloric acid; by .0122 grams per liter for sulphuric acid; and by .0155 and .0576 grams per liter for observers G and H, respectively, in the case of acetic acid. The solutions used as stimuli were obtained by diluting more concentrated solutions whose strengths had been determined from their specific gravities.

The stimuli were kept in small bottles fitted with pipettes, which were refilled daily from stock. These bottles were marked according to a code, so that neither the observer nor the experimenter knew at the time of experimentation with which acid she was working, or which were the stronger and which the weaker solutions. The stimuli were administered according to a chance order. The observer seated herself before a sink. The experimenter then took one of the small bottles, pumped the pipette to stir up the solution, filled the pipette to about

TABLE I

TASTE LIMENS
(Grams per liter)

	Hydrochloric			Sulphuric			Acetic		
Observer	*L*	*c*	*h*	*L*	*c*	*h*	*L*	*c*	*h*
G.....	.0284	1.014	35.7	.0386	1.279	33.1	.0640	.867	13.6
H.....	.0358	1.599	44.7	.0551	1.828	33.2	.1296	1.644	12.7

TABLE II.

AVERAGE LIMENS
(Observers G and H)

	Hydrochloric	Sulphuric	Acetic
Grams per Liter.....	.0321	.0468	.0968
Gram-molecules Normal per Liter.....	.00088	.00095	.00161

one cubic centimeter, and handed it to the observer, who opened her mouth and emptied it upon her tongue. As soon as the observer had formed her judgment, she spat out the solution and rinsed her mouth with distilled water, reporting either "taste" or "no taste." After a maximum of three series, experimenter and observer changed places. Experimentation was never begun less than two hours after a meal, or continued longer than an hour. Series for the three acids were carried on simultaneously, so as to equalize any effects of practice.

The limens obtained are given, together with their measures of precision, in Table I. For further consideration we have averaged the results of the two observers. The average limens are shown on the first line of Table II in terms of grams per liter. On the second line of the table, however, the limens are expressed, not in terms

of the strengths of the acids themselves, but in terms of the concentration of hydrogen-atoms in the liminal solution (gram-molecules normal per liter). It will be seen that the hydrogen-concentration is not constant. The order in which the liminal solutions of the three acids come, in regard to this value, which is necessarily the order of their sapidity as related to hydrogen-concentration, is: Hydrochloric, Sulphuric, Acetic. But this is also the order in which they stand with regard to the percentage of ionization in solution.[8] It is to be noted further that the values for hydrochloric and sulphuric acids differ but slightly, which is in accord with the well-known principle that the inorganic acids tend towards complete (and therefore equal) ionization as the solution becomes very dilute. The concentration of hydrogen in the liminal solution of acetic acid, however, is less than twice that of either of the other two acids. Yet the maximal dissociation of acetic acid in the weakest solutions does not exceed 6%, as against a dissociation approaching 100% for the two inorganic acids.[9]

We must conclude, then, that the sapidity of hydrochloric and sulphuric acids seems to depend upon their concentration in hydrogen-ions (concentration in hydrogen-atoms multiplied by the percentage of ionization), but that acetic acid exhibits a stronger taste than its low ionic concentration would justify. These conclusions are a verification, by a more exact procedure, of the results obtained by earlier investigators.

II. The Daylight Mazda Lamp in the Psychological Laboratory.

By Gilbert J. Rich

It has been shown by Brown[1] that artificial daylight produced by means of Gage's glass may be substituted for natural daylight in color-mixing with only slight effect upon the color-equations obtained. The use of some form of artificial daylight presents many advantages, especially because with it one has a light of constant intensity, a great aid in working out the third law of color-mixture. Many laboratories, however, find the cost of Gage's glass prohibitive. More recently the General Electric Company has placed upon the market a new 'daylight' bulb, the "C-2 Mazda," which sells at prices averaging about 20% above the cost of plain nitrogen bulbs of the same intensity. These prices are within reach of the smallest laboratory, which must in any case spend money for electric bulbs of one sort or another, and can now obtain the 'artificial daylight' with only a slight increase in expenditure. In order to ascertain the value of this new light, we have compared color-matches made under its illumination with matches made in natural daylight.

[8] J. W. Mellor, *Chemical Statics and Dynamics*, 1909, 194f.

[9] Mellor, *loc. cit.* We unfortunately did not have at hand facilities for making a direct determination of the per cent of ionization of the solutions which we found to be liminal.

[1] A. J. Brown, Some Uses of Artificial Daylight in the Psychological Laboratory, *Amer. Jour. Psych.*, 27, 1916, 427ff.